Analysis of Variation in Mechanical Properties of Glass Fiber Reinforced Polymer Concrete

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Abstract

Mixture of cement with a low strength to weight ratio tension and is prone to breaking and scaling, all of which are related to plastic, solidified states, and drying shrinkage. Worldwide a lot of exploration is presently being directed concerning the utilization of fiber overlays and sheets in the maintenance and fortifying of supported substantial individuals. Fiber-supported polymer (FRP) application is extremely compelling method for fixing and reinforce structures that have become fundamentally feeble over their life expectancy. FRP fix frameworks give a monetarily feasible option in contrast to conventional fix framework and materials. In this paper Experimental examinations done on the conduct of the substantial reinforced utilizing irregular hacked glass fiber are done with substantial blend of two unique length of glass fiber (6mm and 12mm) at different rate (0%,0.75%, 1.25% and 1.75%) amount of expansion by the complete load of cement. Trial information on load for pressure, pliable also bending examination has been completed; strength varieties and disappointment methods of every example were gotten.

Keywords. Synthetic Fiber, Waste material, Glass Fiber 6 mm, 12 mm

1. INTRODUCTION

Concrete made with cement is a type of construction element used for underlying components of the building such as pillars, parts, and chunks, among other things. A large number of structures built in the past that use extra highly experienced schedule guidelines through different parts of the world are primarily hazardous as per the new plan guidelines.

Composites of Fiber supported polymers have wind up being amazingly useful for reinforcing of RCC designs to withstand ordinary has well as seismic burdens. One of the challenges in reinforcing substantial designs is deciding on a protective approach for better the design's hardiness & performance while keeping in mind constraints like as buildability, construction works, and budget, adding glass fibre to a concrete mix increases the compressive as well as stiffness of the concrete.

Extra strength might be expected to consider higher burdens to be set on the design. This is frequently required when the fulfillment of the construction changes and a higher burden conveying limit is required. In today's environment, incredibly challenging and hard structural design structures are being developed establish as more amount of Glass Fiber is used in Concrete Mixture is drop the strength of compression and flexural behavior, GFRC is having the high performance and it is environment friendly, GFRC having more service life in comparison to normal concrete but GFRC is costly.

The most important and widely used material is often concrete, and it is required to have very high strength and acceptable functioning features. Significant innovation is being made in this field to foster such cements with unique properties. Establishing as Flexural Strength, Strength properties and Tensile Splitting Strength are increasing in the different time duration. Specialists all around the world are endeavoring to foster elite execution cements by utilizing filaments and different admixtures in concrete up to specific extents. The different variation comes in Flexural Strength, Compressive Strength and in Split Tensile Strength when they use different size of Glass Fiber at different ratio and all have different Stress- Strain Curves.

Many practical have indicate as the cement mechanical properties can increment significantly (by in excess of a significant degree) with the expansion of strands exclusively. This section manages the insights about the survey of writing on examinations relating to glass fiber mechanical properties built up concrete presently numerous trial examinations are having been completed with the expansion of glass filaments of different kind, arrangement, and thickness.

2. Glass Fiber

Glass fibre of varying lengths (6mm and 12mm) is used to obtain varying composite mix (Figure 1). The three different volumetric percentages of 0.75%, 1.25% and 1.75% glass fiber are used in concrete mixture. In this review, an experience made between plain concrete and high strength accomplished by substantial utilizing glass fiber of two lengths (6 &1 2mm) for M25 grade of cement. The test (pressure test, split elastic test and flexural strength test) is to be done on the substantial with the expansion of glass strands of different rates (0.25%, 0.50%, and 0.75%) to add up to weight of the substantial. Blend plan of M25 concrete is to be planned according to IS 10262:2009 and to discover the amounts of fixings.

Figure1. Glass Fiber (6mm and 12mm) [15]

3. CONCRETE MIXING, CASTING AND CURING

Concrete 28-day target strength was set to 31.2 MPa, with a large decline of 75–100 mm planned, according to the blend plan of Indian standard code (IS 10262, 2019). The totals for fine and coarse were in SSD condition. In significant composites, two different lengths of glass fibre (6 mm, 12 mm) & three different volume fractions (0 percent, 0.75 percent, 1.25 percent, 1.75 percent) were used. The plain and composite cements used in this study's blend extents are described in detail. To perform compressive and elasticity tests, a 150 mm concrete cubic shape was produced. Steel molds with a smooth base plate were used to help set up these examples. To test for water penetration during loading, a thin film of form oil was applied to the combination surfaces between the areas of the shape & the base plate of the form. After the shape had been filled with concrete, standard bar was used to finish the temping. A smooth steel scoop was used to create a new significant surface. For 24 hours, the samples were held at a constant temperature. In the aftermath of being free of mold, the samples were smothered in fresh water for 14 and 28 days (Figure 2).

Figure 2. Curing Tank

4. EXPERIMENTAL TEST FOR COMPRESSION

Strength tests were led utilizing pressure testing machine a while later restoring. Pressure test is the appraisal of substantial limit against static burden. The trial of compressive strength was performed utilizing 6-inch (150-mm) 3D shapes by adhering to the rule of IS: 516. During the pressure test, the heap was applied progressively and extreme heap of each substantial example was noted (Figure 3).

Figure 3. Experimental test for compression

5. FIBRE-FORMING PROCESS

A Glass is a formless solid created by cooling rapidly of a liquefy (i.e., fluid stage) to prevent crystallisation (devitrification). Crystallization occur at liquid temperature, TL, where valuable stones & liquefy are in concord, or below, when the soften is gradually cooled. As a result, glass strands are obtained at high cooling speeds. Glass is formed from combining (co-liquefying) silica alongside minerals that contain the oxides needed to make a particular creation. By a process known as fiberization, the liquid mass is rapidly chilled to prevent crystallisation & moulded into glass strands. Almost all consistent glass filaments are manufactured using an immediate draw method & moulded by expelling liquid glass through a platinum composite bushing with thousands of individual apertures ranging in width from 0.793 to 3.175 mm (0.0312 to 0.125 in.).

6. BATCH MIXING AND MELTING

Gauging and mixing of unprocessed components are the first steps in the glass dissolving process. This connection is highly mechanised in today's fiberglass facilities, with automated gauging units and encased material vehicle frameworks. The individual pieces are weighed & transported to a mixing station, where the clump fixings are thoroughly mixed before being transferred to the heater. Fiber-glass heaters are often divided into three distinct components. The cluster is transported into the heater segment for softening, vaporisation, and homogenization. The liquid glass then flows into the purifier portion, where the temperature of the glass is lowered from 1370 degrees Celsius (2500 degrees Fahrenheit) to roughly 1260 degrees Celsius (2300 F). The liquid glass then travels straight over the fiber-shaping stations to the fore hearth segment. The consistency features of the individual glass support the temperatures throughout this contact. Furthermore, the heater's actual design is subject to modification (Figure 4).

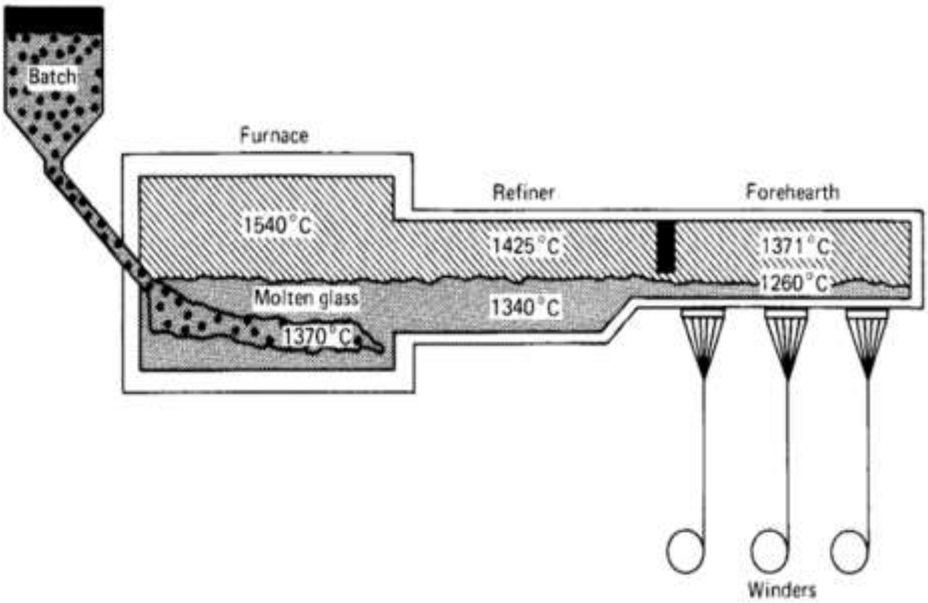

Figure 4. The making of glass fiber [8]

7. SPECIAL PURPOSE PRODUCTS

Glass fibre is used in the construction of basic composites, printed circuit sheets, & a variety of other special-purpose materials. When the nonstop glass strands are finished, they should be transformed into an item structure that is suitable for their intended composite application. The major completed specific reason items are as per the following Fiberglass meandering, Woven wandering, Fiberglass mats, Combinations of a mat and woven meandering, chopped strand items, Milled filaments, Fiberglass paper, Textile yarns, Fiberglass Fabric, Texturized Yarn, Carded Glass Fibers.

8. MIXED DESIGN

Various parameters of the design are listed in Table 1, Table 2 and Table 3. Furthermore various results obtained during compressive strength test are presented in Figure 5, Figure 6 and Figure 7 for different designs.

Table 1: Mix Design of 6mm Glass Fiber

Specimen	Glass Fiber 6 mm(%)	Quantity(kg/m^3)				
		Cement	Glass fiber(6mm)	Water	Coarse Aggregate	Fine Aggregate
M25	0%	448.6	0	197.4	1145.76	677.16
M25+0.75%GF(6mm)	0.75%	448.6	3.285	197.4	1145.76	677.16
M30+1.25%GF(6mm)	1.25%	448.6	5.475	197.4	1145.76	677.16
M30+1.75%GF(6mm)	1.75%	448.6	7.665	197.4	1145.76	677.16

Table 2: Mix Design of 12mm Glass Fiber

Specimen	Glass fiber 12mm(%)	Quantity (kg/m^3)				
		Cement	Glass fiber (12mm)	Water	Coarse Aggregate	Fine Aggregate
M25	0%	448.6	0	197.4	1145.76	677.16
M25+0.75%GF(12mm)	0.75%	448.6	3.285	197.4	1145.76	677.16
M25+12.5%GF(12mm)	1.25%	448.6	5.475	197.4	1145.76	677.16
M25+1.75%GF(12mm)	1.75%	448.6	7.665	197.4	1145.76	677.16

Table 3: Compressive-Strength Test

Specimen	**"Compressive- strength in 7 Days (N/mm^2)"**	**"Compressive- strength in 14 Days (N/mm^2)"**	**"Compressive- strength in 28 Days (N/mm^2)"**
M25	17.12	25.82	29.07
M25+0.75%GF(6mm)	21.02	27.64	31.23
M25+1.25%GF(6mm)	22.18	32.16	34.72
M25+1.75%GF(6mm)	24.37	33.48	36.53
M25+0.75%GF(12mm)	20.58	28.15	30.42
M25+1.25%GF(12mm)	21.18	29.26	31.95
M25+1.75%GF(12mm)	22.13	30.05	32.85

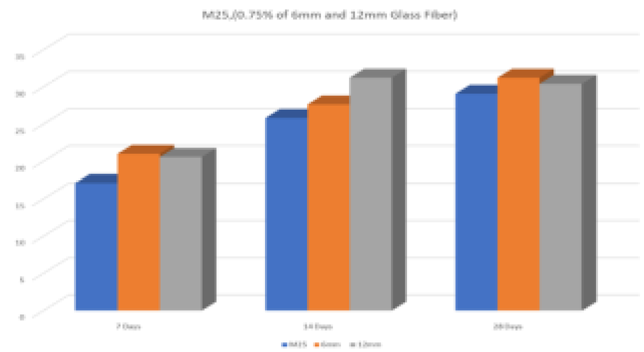

Figure 5: Compressive strength test for dosage 0.75% Glass Fiber

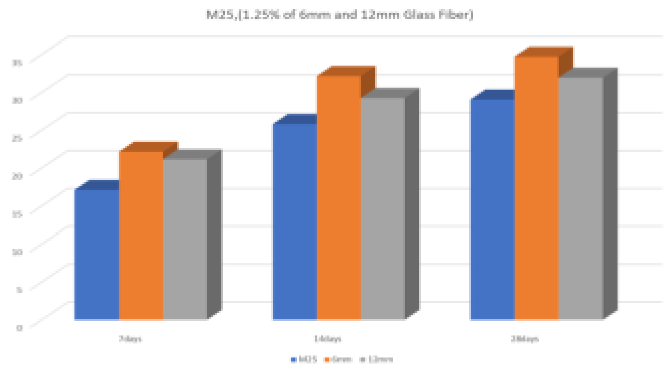

Figure 6: Compressive strength test for dosage1.25% Glass Fiber

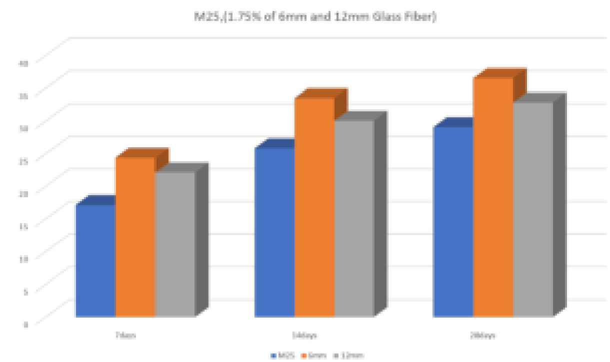

Figure 7: Compressive strength test for dosage 1.75% Glass Fiber

9. DISCUSSIONS

From these results it's clear that high early strength of glass fiber reinforced composite is significantly higher than that of conventional concrete mix regardless of its rate of dosage and its change in size. Other important parameters of significance like higher strength of 6mm based fiber reinforced composite can be explained by understanding basic behavior of matrix (Table 1), that it provides a more homogenous distribution in comparison to that of 12 mm-based composites (Table 2).

12 mm-based composites also acted as a crack bridging secondary reinforcement but its comparatively larger size influenced its homogeneity in comparison to 6 mm alternative, its slump was also significantly smaller, other minor changes also influence its performance. Other possible explanation could be agglomeration of fibers at a single point in composite which can stop proper distribution (Table 3).

A suggestion to properly distribute these fibers would be addition of something like a moderate water reducing admixture because according to technical data sheets and research it's shown that for fiber content beyond 3 kg/m^3 requires moderate water reducing admixtures, this trend follows till the dosage rate of 40 kg/m^3. For dosage rate beyond this value dedicated water reducing admixture should be added.

10. RESULTS

- The Tests on the substantial with and glass strands showed extensive upgrades in properties over the series of expansion of filaments.
- Compressive strength results from change in fiber concentration for a period of 7,14 and 28 days is calculated, and their overall mix consistency, workability and fiber pullout response are observed, which in general shows that the workability decreases with dosage rate and crack bridging effect allows for better mechanical properties than traditional concrete.
- From these results sssss clear that high early strength of glass fiber reinforced composite is significantly higher than that of conventional concrete mix regardless of its rate of dosage and its change in size. Other important parameters of significance like higher strength of 6mm based fiber reinforced composite can be explained by understanding basic behavior of matrix, that it provides a more homogenous distribution in comparison to that of 12 mm-based composites.
- 12 mm-based composites also acted as a crack bridging secondary reinforcement but its comparatively larger size influenced its homogeneity in comparison to 6 mm alternative, its slump was also significantly smaller, other minor changes also influence its performance. Other possible explanation could be agglomeration of fibers at a single point in composite which can stop proper distribution.
- A suggestion to properly distribute these fibers would be addition of something like a moderate water reducing admixture because according to technical data sheets and research its shown that for fiber content beyond 3 kg/m3 requires moderate

water reducing admixtures, this trend follows till the dosage rate of 40 kg/m3. For dosage rate beyond this value a dedicated water reducing admixture should be added.

- From the observed data it can be seen, that for a dosage rate of 0.75%, compressive strength of 6mm glass fiber and 12 mm glass fiber increases by 7.43% and 4.64%. Similarly for the dosage rate of 1.25%, compressive strength of 6mm and 12mm glass fibers increases by 19.43% and 9.91% respectively in comparison to traditional concrete for a time interval of 28 days.

- Lastly for a dosage rate of 1.75%, compressive strength of 6mm and 12mm glass fiber increases by 25.66% and 13.01% respectively in comparison to traditional concrete for a time interval of 28 days.

11. CONCLUSION

The results of using glass fiber with varied cut lengths (6 mm, 12 mm) and varying mix proportions (0.75 percent, 1.25 percent, & 1.75 percent) on concrete compression are presented in this study. The following is a recapitulation of the outcome:

- The most efficient proportion of concrete with glass fiber incorporation was noticed at 1.75% of 6mm size-based glass fiber in which the maximum compressive strength obtained at 28 days was 36.53 N/mm2 for M25 design mix.
- A suggestion to properly distribute these fibers would be addition of something like a moderate water reducing admixture because according to technical data sheets and research its shown that for fiber content beyond 3 kg/m3 requires moderate water reducing admixtures, this trend follows till the dosage rate of 40 kg/m3. For dosage rate beyond this value a dedicated water reducing admixture should be added.
- For dosage rate of 0.75%, compressive strength of 6mm glass fiber and 12 mm glass fiber increases by 22.78% and 20.21%. Similarly for 1.25%, compressive strength of 6mm and 12mm glass fibers increases by 29.55% and 23.7% respectively in comparison to traditional concrete for a time interval of 7 days.
- For a dosage rate of 1.75%, compressive strength of 6mm and 12mm glass fiber increases by 43.18% and 29.26% respectively in comparison to traditional concrete for a time interval of 7 days.
- The Tests on the substantial with and glass strands showed extensive upgrades in properties over the series of expansion of filaments.
- For dosage rate of 0.75%, compressive strength of 6mm glass fiber and 12 mm glass fiber increases by 7.04% and 9.02%. Similarly for 1.25%, compressive strength of 6mm and 12mm glass fibers increases by 24.55% and 13.32% respectively in comparison to traditional concrete for a time interval of 14 days.
- For a dosage rate of 1.75%, compressive strength of 6mm and 12mm glass fiber increases by 29.66% and 16.38% respectively in comparison to traditional concrete for a time interval of 14 days.
- Moreover, optimum incorporation of glass fiber can effectively improve the concrete mechanical properties which may prolong the life of concrete structure.

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Biographies

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Dr. R.K. Tomar is a Civil Engineer with vast industry and academic experience. He graduatedin Civil Engineering from Pune University in 1990 and obtained his master’s in environmental engineering from Delhi College of Engineering, Delhi in 2006.Subsequently, he completed his doctorate from Indian Institute of Technology, Delhi (IITD) in 2015. He has 8 years of industry experience during which he has extensively worked in the field for different projectsrelated to canal, railways and building construction. He has worked for more than 23 years in academia in various capacities as Academic Chair, Center Superintendent and Head of the Department. He holds expertise in the area of solar energy and built environment. His research work focuses on application of artificial intelligence for estimation of solar radiation in buildings.